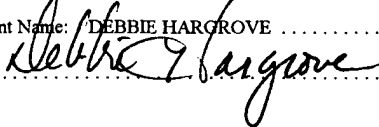


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SYSTEM AND METHOD FOR ADAPTIVE CONFIGURATION OF CELL
STRUCTURE BASED ON THE POSITION OF MOBILE STATIONS

BACKGROUND OF THE PRESENT INVENTION

Field of the Invention

The present invention relates generally to telecommunications systems and methods for reducing interference in cellular networks, and specifically to configuring the cell structure in cellular networks in order to reduce interference.

Background of the Present Invention

In modern cellular systems, the quality of the radio network highly depends upon the interference level in the network. The interference level is usually defined by the carrier to interference (C/I) ratio, which is the ratio of the level of the received desired signal to the level of the received undesired signal. The undesired signal can be a signal of the same frequency from a different cell (co-channel interference) or a signal of an adjacent frequency from a different cell (adjacent channel interference). In either case, the distribution of the C/I ratio throughout the network determines the type of frequency re-use pattern used in the network.

Since the number of frequencies available for cellular telecommunications are limited, frequency re-use patterns are necessary to provide cellular coverage to a geographic region. Frequency re-use is defined as the use of radio channels on the same carrier frequency, covering geographically different areas. Conventionally, these areas must be separated from each

other by a sufficient distance in order to avoid co-channel interference.

However, various mechanisms, such as frequency hopping, power control and DTX, have been developed to reduce the interference in the cellular network without requiring an increase in the number of utilized frequency groups. Therefore, some cellular networks have been able to apply aggressive frequency re-use patterns, such as the 1/3 pattern, which uses only three frequency groups in a single site re-use pattern. These aggressive frequency re-use patterns also provide increased traffic capacity in the networks.

As is understood in the art, the traffic capacity in a cellular network can be increased by utilizing more frequencies or reducing the frequency re-use distance. If the number of available frequencies is limited, the only way to increase the capacity without building new sites is to reduce the frequency re-use distance. However, reducing the frequency re-use distance typically increases the interference in the network. Therefore, in addition to, or instead of,

implementing an aggressive frequency re-use pattern, an overlaid/underlaid sub-cell structure can be introduced in order to increase the radio network capacity.

5 The overlaid/underlaid (OL/UL) sub-cell structure adds a second frequency re-use pattern to the cellular network with a shorter re-use distance than the existing re-use pattern. The cells using this second re-use pattern are typically restricted in size (lower power) to make a shorter re-use distance possible
10 without creating excessive interference. These cells are termed overlaid sub-cells. The original cells that have overlaid cells associated with them are termed underlaid sub-cells.

15 This OL/UL sub-cell structure is created by dividing the available frequencies in the cellular network between the overlaid and underlaid sub-cells. Each overlaid sub-cell serves a smaller area than the corresponding underlaid sub-cell. Consequently, the number of frequencies per cell can be increased, thus
20 providing an increased traffic capacity in the network without building new sites or adding more frequencies.

However, the OL/UL sub-cell structure only works when some of the mobile subscribers are positioned close to the base station. Therefore, in cases where many or all of the mobile subscribers are located near the corners of the cell, away from the base station, the OL/UL sub-cell structure may not provide any real benefit to the network operator or the mobile subscriber. Therefore, there is a need to adaptively switch between the OL/UL sub-cell structure and a normal cell structure, based on the relative position of the mobile subscribers in the cell.

SUMMARY OF THE INVENTION

The present invention is directed to telecommunications systems and methods for adaptively configuring the cell structure of a cell having at least two carrier frequencies between the OL/UL sub-cell structure and the normal cell structure, based on the position of the mobile stations within the cell. The Base Station Controller (BSC) determines the position of the mobile stations within the cell

relative to the Base Transceiver Station (BTS)
location. If the number of mobile stations within a
predefined distance from the BTS is greater than a
channel threshold, the BSC adapts the cell
5 configuration to the OL/UL sub-cell structure. The
channel threshold is an operator-defined percentage of
available channels (throughout the cell or within
either the overlaid or underlaid cell). However, if
the BSC determines that the percentage of mobile
10 stations closer than the predefined distance is less
than the channel threshold, the BSC maintains the
normal cell structure. Advantageously, embodiments of
the present invention reduce the interference and
complexity in the cellular network, while at the same
15 time, increasing the cellular network quality and
capacity.

BRIEF DESCRIPTION OF THE DRAWINGS

The disclosed invention will be described with reference to the accompanying drawings, which show important sample embodiments of the invention and which are incorporated in the specification hereof by reference, wherein:

FIGURE 1 is a flow diagram illustrating the steps for adaptively configuring the cell structure between an overlaid/underlaid (OL/UL) sub-cell structure and a normal cell structure in accordance with preferred embodiments of the present invention;

FIGURE 2 is a block diagram illustrating the OL/UL sub-cell structure in accordance with embodiments of the present invention;

FIGURE 3 is a block diagram illustrating the normal cell structure; and

FIGURE 4 is a block diagram of a base station controller configured to adaptively switch between the OL/UL sub-cell structure and the normal cell structure.

**DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED
EXEMPLARY EMBODIMENTS**

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5 The numerous innovative teachings of the present application will be described with particular reference to the presently preferred exemplary embodiments. However, it should be understood that this class of embodiments provides only a few examples of the many advantageous uses of the innovative teachings herein.

10 In general, statements made in the specification of the present application do not necessarily delimit any of the various claimed inventions. Moreover, some statements may apply to some inventive features but not to others.

15 With reference now to the steps listed in FIGURE 1 of the drawings, which will be described in connection with FIGURES 2-4 of the drawings, a mechanism for adaptively configuring a cell 22 having at least two carrier frequencies (f_1 and f_2) associated

20 therewith is shown. As a first step, the network operator for the cell 22 must first define a distance threshold 25 (step 100). This distance threshold 25 is

preferably associated with a specific radial distance
from a Base Transceiver Station (BTS) 24, as is shown
in FIGURE 2. The BTS 24 is shown for simplicity as an
antenna, but should be understood to include all radio
5 equipment needed for the cell 22.

As a next step, the network operator must also
define a channel threshold 26 (step 110), which
corresponds to an operator-defined number of traffic
channels that are either in use or available. The
10 decision as to whether the channel threshold 26 is
associated with the number of available traffic
channels or the number of traffic channels in use is
also made by the network operator. Once defined, both
the channel threshold 26 and the distance threshold 25
15 are stored in a Base Station Controller (BSC) 23
serving the BTS 24, as shown in FIGURES 2-4.

It should be understood that traffic channels
carry speech and other data between the BTS 24 and
Mobile Stations (MS's) 20a and 20b, which are the
20 equipment used by the mobile subscribers to communicate
with the cellular network. These traffic channels are

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a type of logical channel that is mapped onto a time slot of a specific carrier frequency f1 and f2. The number of time slots depends upon the type of cellular system. For example, in the Global System for Mobile Communications (GSM) system, each carrier frequency f1 and f2 is divided into eight time slots, with at least one time slot reserved for signaling information between the BTS 24 and the MS's 20a and 20b and the other seven time slots available as traffic channels.

10 Thus, the channel threshold 26 represents a percentage of logical channels allocated as traffic channels that are either in use or available. In addition, the channel threshold 26 can be set based upon the total number of traffic channels for all of the available carrier frequencies f1 and f2 in the cell 22, or upon only the number of traffic channels for one or more of the available carrier frequencies f1 or f2 in the cell 22.

15 The channel threshold 26 distinguishes between a cell 22 that has a number of MS's, e.g., MS 20a, close to the BTS 24, in which case an overlaid/underlaid

(OL/UL) sub-cell structure can be applied, and a cell 22 that does not have many MS's, e.g., MS 20b, close to the BTS 24, in which case the normal cell structure should be applied. The OL/UL sub-cell structure works well in the situation where a number of MS's 20a are close to the BTS 24. If there were few or no MS's 20a close to the BTS 24, changing to an OL/UL sub-cell structure would not be beneficial, as the traffic capacity in the cell would be effectively decreased.

Once the distance threshold 25 and channel threshold 26 are defined, the process of adaptively configuring the cell 22 can begin. Initially, the BSC 23 starts with the normal cell structure, in which all of the available carrier frequencies f1 and f2 are active across the entire area of the cell 22. Thereafter, as shown in FIGURE 4, measurement logic 400 within the BSC 23 measures a distance D1 and D2 of each of the MS's 20a and 20b, respectively, involved in a call connection in the cell 22 from the BTS 24 (step 120). For example, the BSC 23 can obtain a respective Timing Advance (TA) value from each of the MS's 20a and

20b, which provides the BSC 23 with a respective radius around the BTS 24 that each of the MS's 20a and 20b is located within, and use these respective radius' as the distance measurements D1 and D2, respectively.

5 Alternatively, the BSC 23 can obtain coordinate location information for each of the MS's 20a and 20b using a network-based positioning method or an MS-based positioning method, such as the Global Positioning System (GPS), and determine the respective distance D1
10 and D2 from the BTS 24 based upon this coordinate location information.

Once the distance from the BTS 24 for each of the MS's 20a and 20b involved in a call connection is known (step 120), as shown in FIGURE 4, the BSC 23 inputs
15 each of these measured distances D1 and D2 to comparison logic 410, which compares each of these distances D1 and D2 with the distance threshold 25 to determine the number of MS's 20a and 20b having a respective distance D1 and D2 from the BTS 24 less than
20 the distance threshold 25 (step 130). For example, the

distance threshold 25 can be the radius of a desired underlaid sub-cell 22b, as shown in FIGURE 2.

Thereafter, the BSC 23 inputs the determined number of MS's 20a and 20b having a distance D1 and D2, respectively, from the BTS 24 less than the distance threshold 25 to additional comparison logic 420, which compares this number to the channel threshold 26 (step 140) to determine whether to change the cell structure to the OL/UL sub-cell structure (step 150). If the additional comparison logic 420 determines that the structure of the cell 22 should be changed to the OL/UL sub-cell structure, an output 422 of the additional comparison logic 420 goes to configuration logic for the OL/UL sub-cell structure 430, and the cell structure is changed to the OL/UL sub-cell structure (step 160). Otherwise, an output 424 of the additional comparison logic 420 goes to configuration logic for the normal cell structure 435, and the normal cell structure is maintained (step 170).

In one embodiment, if the channel threshold 26 is defined as a certain number of traffic channels in use,

and if the number of MS's 20a having a distance D1 less
than the distance threshold 25 is greater than the
channel threshold 26, the output 422 from the
additional comparison logic 420 goes to the
5 configuration logic 430 that changes the cell structure
to the OL/UL sub-cell structure. For example, if the
channel threshold 26 is three traffic channels in use,
and there are five MS's involved in call connections
within the cell 22, four of which have a distance less
10 than the distance threshold 25, the BSC 23 would change
to an OL/UL sub-cell structure.

In an alternative embodiment, if the channel
threshold 26 is defined as a certain number of
available traffic channels, the BSC 23 would change to
15 an OL/UL sub-cell structure only when the number of
MS's 20a and 20b involved in call connections having a
distance D1 and D2, respectively, to the BTS 24 less
than the distance threshold 25 is less than the channel
threshold 26. For example, if the channel threshold 26
20 is five traffic channels available, and there are five
MS's involved in call connections within the cell 22,

four of which have a distance less than the distance threshold 25, the BSC 23 would change to an OL/UL sub-cell structure.

An example of an OL/UL sub-cell structure is shown in FIGURE 2. Since the BTS 24 has at least two separate Transceiver Units (TRUs) TRU1 and TRU2, each having a different carrier frequency f1 and f2, respectively, associated therewith, TRU1, which has frequency f1 associated therewith, becomes associated with an underlaid sub-cell 22a, which serves the entire area of the cell 22. In addition, TRU2, which has frequency f2 associated therewith, becomes associated with an overlaid sub-cell 22b, which serves a smaller area of the cell 22 than the underlaid sub-cell 22a.

This OL/UL sub-cell structure is accomplished by lowering the BTS 24 power of TRU2 with respect to the BTS 24 power of TRU1. Advantageously, by changing to an OL/UL sub-cell structure, the traffic capacity in the cell 22 remains the same, but the interference in the cell 22 decreases, due to the smaller size of the

An example of a normal cell structure is shown in FIGURE 3. The normal cell structure has multiple TRU's TRU1 and TRU2, each with the same power, so that all of the carrier frequencies f_1 and f_2 , respectively, can serve the same area (the entire area of the cell 22). In this case, any MS 20a or 20b anywhere in the cell 22 can be assigned to a traffic channel on either TRU1 or TRU2, and thus communicate with the BTS 24 over either available carrier frequency f_1 or f_2 , respectively. Although the traffic capacity in the normal cell structure is the same as in the OL/UL sub-cell structure, the interference in the normal cell structure may increase due to the shorter frequency re-use distance of all carrier frequencies f_1 and f_2 .

20

having three antenna pointing azimuths (not shown), one
for each cell. In these situations, the overlaid sub-
cell 22b usually extends radially out from the
intersection of the three cells to a diameter smaller
5 than the diameter of the underlaid sub-cell 22a.
Therefore, in order to accommodate these type of
frequency re-use patterns, instead of defining a
specific distance from the BTS 24 as the distance
threshold 25, the distance threshold 25 can be a
10 function describing the shape of the desired overlaid
sub-cell 22b.

With reference again to the steps listed in FIGURE
1, and the BSC 23 diagram of FIGURE 4, once the cell 22
has been configured, the BSC 23 can either repeat the
15 process immediately, or preferably, to reduce the
amount of processing within the BSC 23, the BSC can
initialize a timer 440 having a period set by the
network operator (step 180). Upon the expiration of
the timer 440 (step 190), the BSC 23 repeats the
20 process, and obtains new distance measurements D1 and

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D2 for all MS's 20a and 20b currently involved in a
call connection in the cell 22 (step 120).

As will be recognized by those skilled in the art,
the innovative concepts described in the present
5 application can be modified and varied over a wide
range of applications. Accordingly, the scope of
patented subject matter should not be limited to any of
the specific exemplary teachings discussed, but is
instead defined by the following claims.

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